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ABSTRACT

This study assesses the composition of micro-level behaviours embedded within innovation clusters. Drawing on network theory of innovation, we examine the relational complexities of a specific university-business form of clustered exchange to characterise the actor level behaviours that influence the breadth and spread of network involvement. Whilst some current research posits behavioural attributes of clustered networks, there have been few studies that have focused on the extent of influence that individuals have on the development of value creating relationships, the roles individuals play and the various factors that have the potential to impact their effectiveness. This conceptual development study provides insights into the actor-level behavioural features that play a central role in promoting the innovation effectiveness of these regions. The findings of this three year long ethnographic study suggest that in the face of resource constraints individuals act as agents in creating and sourcing external input for the benefit of their projects. This has implications for policy-makers as well, as our findings suggests that policies should be shaped to provide enabling factors for boundary-spanning, thus allowing relationships to be equipped with the ability to manage complex partner contexts to access the benefits of diversity.

Keywords: network theory, agency, clusters, university-business, open innovation

Developing Relationships in Innovation Clusters: Insights from a Business-University Case Study

INTRODUCTION

Cluster formation activities have had a major impact on regional development (Li, Goetz, Partridge and Fleming, 2016) because of their ability to foster innovation in firms (Oerlemans, Meeus, and Boekema 2001) and the accelerated knowledge spill-over effects they have on local economies (Knott, 2003; Baptista and Swann, 1998; Jaffe et al., 1993). This is an important matter because an increasing number of political agendas around the globe (e.g. UK Industrial Strategy, 2017) hope to influence the innovation landscape and stimulate economic growth by investing in incentives for regional cluster activities (Salter and Martin, 2001; Metcalfe, 2010; BIS, 2012; Wilson Review, 2012). The primary focus of these policies and incentives is to foster collaboration through co-located MNCs, SMEs, Universities, and Research Institutes. While this *may* present opportunities to access diverse and heterogeneous knowledge within the network (Granovetter, 1973; Burt, 1995; Knott, 2003), its success is far from guaranteed. The staggering development rates and disappointing return figures indicate that there are significant risks of lost investment due to ineffective cluster formations (Isaksen, 2018). This disappointment can be associated with a failure to understand the relational subtleties needed to realize value within cluster formations (e.g., Hassink, 2017; Hughes, Ireland and Morgan, 2007). Questions regarding how the government can facilitate localised support and foster collaboration remain prevalent (Department of Business, Energy, and Industrial Strategy UK, 2017). Now more than ever, there is an utmost importance for research to focus on relational design and configurations to enhance our understanding of cluster effectiveness and for the development of strong policies.

In light of this problem, it is perhaps unsurprising that recent research efforts have been directed towards understanding the alignment factors that drive cluster formation and increase their prevalence (Porter and Ketels, 2003; Uyarra and Ramlogan 2016). Yet, it is not enough to understand the preliminary conditions, found within geographic regions and/or facilitating factors conducive to cluster formation (Isaksen, 2016). While research advancements within this regard have contributed to a more a comprehensive approach to managing and coordinating the multi-faceted nature of cluster formation, we must also know what conditions favour cluster continuation, effective cluster functioning, and the realization of value from the opportunities they provide. Regrettably, these factors have yet to receive much empirical attention, rendering our knowledge of the functioning, survival, and flourishing of clusters inherently incomplete.

The advantages of locally-specific resources are important to firms (Porter, 1990; Baptista and Swann, 1998; Engel, 2015), but they are not always conclusive to cluster activity (Mueller, Westhead, and Wright, 2012). In clusters, members participate when it is apparent there is a win-win effect at play. When effective, clusters improve firms' access to information, knowledge, resources, and institutions (Sammarra and Biggiero, 2008). When ineffective, the cluster risks becoming little more than the co-location of firms in which resource, knowledge, and innovation advantages are sought but not appropriated (e.g., Duc and Lindeque, 2018; Howells and Bessant, 2012). This is because cluster effectiveness is dependent upon the processes through which relationships form within and among individuals at the micro-level of the networked cluster. By using an inter-organizational network theory lens, we can readily acknowledge that variance in value realization (within any relational context) has the potential to impact the effectiveness of inter-firm collaboration. The cluster formation literature has yet to explore the behaviours of these networked interactions in-depth and this represents our baseline proposition: successful value

realization within clusters relies on the behavioural activities of individuals (operating at the micro-level) and greatly influence the effectiveness of regional clusters by identifying and sourcing solutions to their resource gaps. To the best of our knowledge, there has not been a study that explores the dynamics of micro-level relationships within clustered activities in depth to full understand the roles that individuals play within this regard.

We respond to this gap by asking three related research questions: (1) How might individual actors (agents) influence the ways in which clusters are organised and coordinated to ensure innovation? (2) How do actors within relational dyads form network effects to engage in relationships within and beyond the cluster? (3) What are the roles of external actors representing extra-cluster relationships in shaping innovation within a cluster? With data from a three-year long, in-depth ethnographic examination of an influential inter-organizational dyad, embedded within a regional cluster, and highly lauded for its effectiveness, we reveal how actors develop linkages within and build the extent of the network boundaries beyond a focal dyadic exchange. Framing the study around a solitary inter-organizational dyad provides several advantageous views of the fine-grained micro-level processes that occur within an integrated and complex collaborative knowledge exchange network. First, the richness of the data collection exercise allowed for robust observations of the genuine social interactions occurring and allowed for a more naturalistic definition of the cluster boundaries and boundary spanning activities. Second, an inclusive view of the micro-level components and processes offered the opportunity to advance conceptual understanding of relational functionality, durability and effectiveness that the relational dyad exhibited. Thus, we contribute much-needed new information on the determinants of cluster effectiveness by focusing on individual agency, agents' boundary-spanning activities and the impact that relationship governance structures may have on the innovation performance, management, and outcomes.

THEORETICAL BACKGROUND

A Network Theory View of Clusters

A relational network structure, built between two organizations, is often inter-twined with and impacted on by a wide variety of external influences (Krugman, 1991), and in ways that potentially influence the emergence, management, and coordination of the innovation process (Wasserman and Faust, 1994; Granovetter, 1973 Burt, 1995). Indeed, the scale of diversity in knowledge resources and relational linkages available within a cluster presents the opportunity for novel insights to emerge (e.g. Granovetter, 1973; Burt, 1995). However, the ability to capture the inherent collaborative value of that clustered network lies within the inter-operability of the individual agents and the ability to coordinate the scale of the interactions. This requires a focus on the individual (Zaheer, McEvily, and Perrone, 1998) because it is individuals that ultimately act within any clustered (network) structure. However, the role that actors play within the micro-level network structure is repeatedly overlooked despite the fact that the interplay of authority, legitimacy, and leadership they present directly impact the performance of core and non-core actors (Kadushin, 2011). Therefore, the value of inter-organizational relationships is contingent on managing the contextual complexity among actors within the relationship or cluster (Meuller and Jungwirth, 2016). Understanding the relational behaviour of individual agents and the conditions in which their boundary-spanning occurs is vital to understanding the effectiveness of clusters and determinants of sustained innovation within clusters.

The relational behaviour of agents is conditional upon managing the social complexities of clusters to favour the formation of innovations among firms. Ultimately, the realisation of value depends on the extent to which the relationship(s) within a cluster creates and facilitates productive social relationships among the actors within and beyond the cluster

(Adler and Kwon, 2002; Inkpen and Tsang, 2005; Hughes and Perrons, 2011; Hughes et al., 2007; Nahapiet and Ghoshal, 1998). These induce productive relationships that affect the performance of innovative outcomes (Kale, Singh, and Perlmutter, 2000; Mooi and Frambach, 2012; Sisodiya et al., 2013). In a network view of an innovation cluster, actors are embedded in a coupled and interdependent structures of relational exchange (Gulati, 1995). This is because the route to innovation is contingent upon complex human and social interactions that must be aligned and coordinated to access, release and generate knowledge necessary for value realization (Kogut and Zander, 1992; Noaka, 1994; Rodan and Gullunic, 2004). To date, much of the cluster research aims to understand the macro-level structural influences (e.g. geographies and local resources) and the subsequent performance and success of market-based knowledge transactions (Eisengerich et al., 2010; Mudambi et al., 2018). Often, studies approach this phenomenon from a symbiotic relational lens (in which organizations are engaged in relationships via contracts or hierarchies) and has advanced our understanding of early alignment factors and their subsequent effects on knowledge spill over activity (Isaksen, 2018; Acs and Audretsch, 1990). Yet, the studies have yet to fully assess the complex contextual features of the relationships held and often imply a simplification of a complex phenomenon. In other words, scholars have tended to treat the problem of cluster effectiveness at the macro level of analysis instead of at the micro level. The micro level appreciates that cluster effectiveness (in terms of innovation) relies on deciphering the complex social system to untangle the genuine dynamism of collaborative exchange.

As a corollary of this matter, many cluster research studies focus solely on the transfer of knowledge between clustered organizations through licencing or a consultancy project (Chesbrough, 2003; Melese et al., 2009). Generally, the studies imply that firms participate in such a cluster to gain access to upstream knowledge bases rather than technologically-specific product knowledge (Feller, Ailes and Rossener, 2002). This indicates an underlying

assumption that relationships can be enacted and managed most effectively through formal mechanisms, in which assumptions of relational (over)dependence for resources exacerbates a party's power (Provan et al., 2007). While studies are not unanimous in their concerns about relational dependence (Looy et al., 2004; Goldfarb, 2008), they are generally consistent in sharing an antagonistic view of inter-organizational relationships as a zero-sum game originating from one partner's inherent vulnerability to the actions of the other (Ireland et al., 2002): for one to gain, another must lose.

In contrast, the vitality of relational behaviour has been strongly associated with providing an environment conducive to knowledge exchange and relational development (Carmeli and Azeroual, 2009; Huemer, 2014). Networks of relationships, from within and beyond a cluster, are not static. The oscillation and development of linkages with new members and internal/external pressures influences the resources and knowledge available for exchange and recombination (Nonaka, 1994; Hughes and Perrons, 2011), and thus will impact the effectiveness of innovation performance over time (Ng and Feldman, 2010). This dynamism exhibited by the individual actors will affect the way clusters are organised and the effectiveness of any structure put in place. By further exploring the agency of the individual members of clusters, a richer conceptualisation can be made of the facilitating (or inhibiting) factors impacting new resource acquisition and ultimately innovation.

As mentioned previously, organizations enact and maintain relational exchanges for the benefit of their firm. The actors, embedded within firms, recognise the potential incentives and benefits of engaging within clustered forms of activities (e.g. the access to knowledge spill overs and diverse resource stream access), yet also the potential for asymmetric gains due to variations across organizational contexts and the processes of value realisation. This becomes even more complex when the sought benefits of relational exchange are set to yield an uncertain innovation payoff or performance metrics, as the

promise of novelty cannot be guaranteed. Within the innovation scope, agents will attempt to minimize the risks of sunk transaction costs and maximise the likelihood of knowledge resource acquisition for the benefit of their own projects. In the process of assessing their own resource gaps, the agents will source, develop, and enact various relationships to maximise their potential payoff and minimise risk. Whilst the clustered activities might provide environments for technical contexts to be developed, the function of the relationships is what enables the knowledge to be disbursed and exchanged. It is essential to understand how these relationships work in practice, and the core components of actor-level perceptions of relational development.

The Role Business-University Interactions in Clusters

Universities have long been acknowledged as regionally-embedded resources for innovation activity within clusters, both by policy-makers and scholars (Debackere and Andreies, 2003; Feller, Ailes, and Rossner, 2002). They represent a particularly potent source of open innovation (Ivascu, Cirjaliu, and Draghici, 2016). But there are significant risks of misalignment between university and business actors due to variations in their economic objectives. Yet, the research in this area has focused on the performance outcomes of complex funding structures within asymmetric university-business relationships and within specific geographies (Benner and Sandstrom, 2000; Etzkowitz and Leysdesdroff, 2000; Park and Leysdroff, 2010; Hicks, 2012), at a cost to understanding individual agency.

Business-University clusters are unusual because the two protagonists behind the cluster are heterogeneous, whose only common interest is where each other's knowledge overlap. For example, academic research, conducted within the remit of university laboratories, has a primary focus towards expanding knowledge bases through theoretical development, whereas commercial research is aimed towards the pursuit for answers to specific problems or technological advances (Rosenburg and Nelson, 1994; Lee and Ling,

2007). When one partner is also a multinational enterprise, their co-location (and clustering) behaviour is also driven by strategic asset-seeking motives (Duc and Lindeque, 2018; Mudambi, Narula, and Santangelo, 2018). However, variances present risks for complexities in creating the alignment and coordination needed for innovation (Kogut and Zander, 1992). These circumstances in their collaborative situation create a demand for governance structure facilitating shared control and management (Inkpen and Tsang, 2005; Parkhe, 1993).

This assumption is apparent within the body of evidence that suggests university-business relationships are developed through contract-based arrangements (Chesbrough, 2003; Huizingh, 2011; Hossain, 2012; Ye and Knakanhalli, 2013). Research on university-business relationships are typically focused on understanding the impact of formal mechanisms on the tangible outcomes of this type of relationship. For instance, there is a large and growing body of literature that focuses on the impact of funding structures on the generation of intellectual property (Benner and Sandstrom, 2000; Etzkowitz and Leysdesdroff, 2000; Park and Leysdroff, 2010; Hicks, 2012). In these studies, performance is related to capabilities to engage with legal context and appropriately manage intellectual property. Formal governance mechanisms constitute ‘hard’ factors geared towards managing the effectiveness of university-business clusters. But, informal or relational governance mechanisms that support knowledge exchange within this type of partnership (e.g., methods of operation within the relationship, the development of trust, opportunity identification and exploitation therein, etc.) (Klawe, 2011; Cheng and Huizingh, 2014) are essential for individual agents in that social mechanisms can drive the performance of agents (North, 1990).

A cluster does not impose contractual governance. Instead, organizations create individual contracts at the local level that meet the needs of individuals to organize and predict the desired economic activity as best as possible (Williamson, 1973, 1978). These are

often inefficient, however, because of their inability to precisely specify all possible situations and contingencies. As core actors in regional innovation clusters, University-Business relationships are widely embedded within a broad range of innovation channels and networks. This provides the network with benefits of resource diversity; however, the scope of their activities increases complexity of coordination and presents the potential for missed opportunities or for innovation to fail to materialize (Marriotti and Delbridge, 2012). This complexity requires appropriate relational governance to support individual agents to shape collaboration and begin complex knowledge transfer (Uzzi, 1996, 1997). This position is consistent with the principle that the value of knowledge acquisition is largely dependent on the composition of the knowledge shared in the micro-level network between the individuals interacting (Polyani, 1966). These relational links must be appropriately managed to access and coordinate the resource available within.

Processes of innovation and knowledge sharing occur at the micro level and are dependent upon behavioral and contextual conditions needed to facilitate diverse and collaborative knowledge exchange (Ozcan and Islam, 2004). Yet, there are several significant and powerful external forces acting on these individual agents, and the management and coordination of those external institutions can have a significant bearing on internal behaviour, opportunity identification, and internal management. With each partnership developed and maintained over time, the intensifying exogenous pressures on the normative behaviours and social interactions of individual agents impact either the sustainability of the relationship as a whole or its performance. We now move to review the conditions in which actors are capable of enacting and maintaining diversity (for enhanced resource access) and relationships (for enhanced knowledge sharing).

Network Conditions in the University-Business Relationship

A network view recognizes that organizations are positioned between and among populations of other organizations to share some form of resources or capabilities (Powell et al., 1996; Barringer and Harrison, 2000; Laursen and Salter, 2006), in response to some form of uncertainty or external pressure (Jones et al, 1997), and through inter-industry spillover activities (Krugman, 1991). While existing within macro-environmental contexts, the relational exchanges function at the micro-individual level (Zaheer et al., 1998). The benefit of engaging within a network (or a network view of an inter-connected cluster) lies within the flexibility for organizations to remain a semi-autonomous node in their area of specialism (Bluedorn et al., 1994) whilst also accessing the regional resource pool (Powell, 1990; Daata, 2011). Through a process of communication and information diffusion, firms access or transmit ideas and other forms of knowledge within networks of external relationships, that can be shared or accessed among the focal actors (Daata, 2011) to learn faster (Dyer and Hatch, 2004) and to promote innovation (Chang, Chung, and Mahmood, 2006; Mooi and Frambach, 2012). As previous research suggests, the early alignment factors impact the vitality of this exchange.

As relationships gravitate towards embedded network forms, hierarchies and control mechanisms become alternatives to contractual mechanisms (Powell, 1990). This recognises that behavioural uncertainty and the unpredictability of potential partners negates the likelihood that contracts are fully inclusive (Zaheer and Venkatraman, 1995). In doing so, this offers space for idiosyncratic activity that would otherwise be prevented when relying solely on contracts. The cluster has the potential to transcend merely a co-location of actors and allows for an ecosystem for innovation that accepts the collaborative and social elements of knowledge generation in the innovation processes. At that point, overly-formalised and rigid relational agreements might inadvertently subvert the spontaneity and flexibility necessary for innovation to occur (Sivadas and Dwyer, 2000; Slater et al., 2014). Forecasting the

dynamics necessary to fuel innovation activity is ambiguous such that overly-formal and rigid relational agreements result in excessively deterministic expectations.

Facilitating factors either impose constraints or facilitate collective action within supra-level social structures and has been used to understand the impact of external environments on the behaviour of firms operating within different nations (Scott, 1987; 2008; Mueller and Jungwirth, 2016). Institutional pressures serve as a basis for authority, in which partners must conform to legal, socio-cultural, and political norms. The individual actors will seek to gain legitimacy in their environment through cultural and cultural conformism to not only the external environment but also to the more dominant network structure (Scott, 2008) and develop social norms (e.g. culture), behaviours and relational interactions accordingly (DiMaggio and Powell, 1983; Suchman, 1995). However, the development of overly-institutionalized relationships can unintentionally create network barriers to knowledge exchange (Meyer and Rowan, 1977; Allen and Strathem, 2005; Dyer and Hatch, 2004). This is because rigid practices and policies might not enable relationships to be identified and formed autonomously. How core relationships emerge and behave in regional innovation clusters (and beyond) is not well understood, yet the importance of understanding the components of how this works to generate value cannot be under-stated.

METHODOLOGY

To address the question of how individual agents influence the ways in which clusters are coordinated and enact innovation, this study used a social structuration logic and utilizes a methodology that permits an in-depth network analysis. This research design was selected to account for how variances within the structure of social relations might present opportunities or constraints to actors embedded within dyads and clusters (Hanneman and Riddle, 2005; Carrington and Scott, 2012). Therefore, we acknowledge the duality of network structure and

its embedded agents, the inseparability of the macro- and micro-level manifestations within some phenomena, and thereby provide an inclusive view of how these interactions manifest within the phenomena. The actors and their actions embedded within the phenomena of interest are interdependent and are characterised by a variety of relational structures. Specifically, instead of analysing individual behaviours, attitudes, or beliefs, this methodological consideration permits the opportunity to enhance theorisation of how these interactions constitute a framework or structure that can be studied and analysed (Galaskiewicz and Wasserman, 1994).

In studies that frame the structure of networked relations, researchers have a range of techniques to identify and study the boundaries of internal and external members (Wasserman and Faust, 1994; Cross and Parker, 2004; Kadushin, 2011; Carrington and Scott, 2012). However, the initial assumptions of network boundaries often dictate study samples and present researchers with significant limitations in capturing the true nature of boundary spanning activities. In addition, studies can often be limited by the lack of access necessary to reveal multiple levels of relational channels and the interaction that impact behavioural outcomes. This occurs when presented with access and time compressions to manage the volume and complexity of the data collection and analysis (Kadushin, 2011). Previous research often acknowledges that the extent of the network influence and activity extends beyond the sample collected. Therefore, we provide a rich description of the research design set in place to crystalize the network structure of a particularly successful example of a university and business relational dyad in its entirety. The intention is to describe the ways in which certain features might influence outcomes from within an active network and in a systematic way. This is necessary to illustrate the complex dynamics and interactions among network structure, content, and behaviour on both sides of a relational dyad (Wasserman and

Faus, 1994). Therefore, the method triangulates multiple data sources to enhance the reliability of the interpretations generated through subsequent data analysis.

Case Method

The outputs of this study is to provide a conceptual advancement of the micro-foundations of these relational structures, and the circumstances surrounding their effective functioning, continuation, and the creation of valuable innovations. The case method was chosen because it offers the opportunity to view the process at which human behaviour enacts and forms innovation clusters on a micro-level and make recommendations for further deductive examination (Glaser and Strauss, 1967; Eisenhardt, 1989). Network researchers assess a variety of contextual and situational factors, and case research enables an in-depth examination of the complex features of inter-organizational exchange unavailable through other means (Dubois & Araujo, 2007; Halinen & Törnroos, 2005). The author was afforded with rare access to the entire case company and cluster for data collection (Yin, 2013).

To further enhance the reliability of the data, the research was designed to capture evidence of the conditions in which behaviours emerged using a longitudinal lens (Hughes and Perrons, 2011; Pettigrew, 1997; Yin, 2013). We observed a large-scale business-university relationship from the point of the initiation of its strategic governance. The study ran from October 2013 to the January 2016. The single research site method is particularly suitable for longitudinal studies (Eisenhardt, 1989; Yin, 2013). When coupled with social network analysis, it fits the purpose of understanding how the relationships within the cluster occurred and evolved over time, with reference to events and changes unfolding within the cluster/relationship (Van de Ven, 2007). This afforded a rich treatment of the phenomenon (Siggelkow, 2007) to provide in-depth insights relevant to answering our research questions.

Research Site

The case was chosen for theoretical sampling purposes and not population sampling. The case and research site selected for empirical investigation is a highly-regarded, award-winning university-business innovation relational dyad. The case was further chosen as it represents a timely, revelatory example of the development and maturation process of an influential relational dyad and the interactions they create and manage within cluster activities. The participants of the study were embedded within the focal point of the networked activities in a Northern England (U.K.) regional cluster. The business organization studied operates on a global scale in the fast-moving consumer goods industry. The university organization in question is a strong institution of international repute. The business-university cluster has been highly lauded, not only by members of the relationship in both organizations, but also by broader external entities. In the time period of the study, the relationship had generated in excess of £20M, and leveraged over £10M in governmental and research council support. It is cited and presented as an exemplar case study for industrial engagement amongst the highest tiers of policy-makers within the United Kingdom and the United States. From 2011 through 2016, the relationship had developed and was managing 66 funded projects with 162 individuals embedded in the focal relational dyad. These projects were scaled across a variety of knowledge transfer and acquisition targets and included individuals from both organizations collaborating on projects in the areas of chemistry, physics, biology, psychology, business, mathematical sciences, and history. The relationship also involved key administrative staff, including technology transfer, finance, and legal.

This particular university-business relationship had been developed in response to geographic proximity and the availability of shared resources. The relationship initiated pilot studies in 2011 to test the feasibility of developing a scaled and multi-faceted inter-organizational knowledge exchange network. Between 2011 and 2012, many aspects of the

micro-level functioning relational dyad emerged organically and in response to a variety of internal and external stimuli. Recognizing the value and performance of this exchange, the relationship developed a strategic intent to further scale, coordinate, and maintain the vitality of the partnership. Realizing that the relationship developed through a variety of self-organizing processes, the partners were keen to ensure that the momentum at which the relationship scaled was sustained and operating efficiently. In 2013, the relationship developed an executive board for governance procedures, relational oversight, and the development of further opportunities. It is at this stage that data collection began.

Data Collection

The generous access and opportunity to explore this case in-depth provided rare insights into the effective functioning of the relational exchange and its behaviour within clustered activities. To address typical boundary specification limitations within previous research (Hanneman and Riddle, 2005), and to reveal the extent to which internal and external engagement occurs, the first phase of data collection employed a snowballing data collection method technique and focused on providing an ego-centric view (Prell, 2011). The aim was to reveal the composition of actors within the idiosyncratic pockets within the collaboration (Wasserman and Faust, 1994). In employing the ego-centric approach, data collection focused on compiling data with direct interactions with the network on either side of the relational dyad and beyond. This gave the opportunity to assess the compositional elements of the network, such as human contextual considerations and the intensity of specific relational ties. The ego-centric approach to analysing network data is most effective when several data points are triangulated. Therefore, data collection techniques involved multiple sources of evidence, including documents, interviews, and participant observations to enable triangulation as well as enhance data accuracy and reliability.

Semi-structured interviews were focused on understanding the role of key actors and used to identify the actors' history with the relationship, their views on the inner working of the network, how it formed, significant events, challenges, and benefits, and what they thought were the highest functioning aspects of the relationship to further contextualise how and why the relationship formed and is maintained. These interviews drew on open-ended questions to prevent steering of interviewees' responses and to allow for a conversational mode to understand each participant's world and views of the relationship more deeply. As suggested by Silverman (2015), this format allowed the actors to make authentic representation of their views of the world and vocalize their priorities whilst allowing the researcher to be non-directive and remain neutral. As part of the protocol, a template of questions was generated in advance and aimed at understanding how the relationship was built. The interaction was constructed through interactive dialogue and additional questions were asked as called for to address the potential for duality and multiplicity of meaning. Key informants checked the validity of statements during the composition phase. Where appropriate for data validation or clarification, interviewees were approached for a second, follow-up interview (Gephart, 2004, Miles and Huberman, 1994).

[Insert Table 1 Here]

Participant observations borrowed from anthropological research methods, in that they focus on obtaining data first hand (Silverman, 2015) over the three-year period. This technique derived the social conditions of the business-university relationship through immersion in the research site whilst also allowing the researchers to engage within the relationship as appropriate (Yin, 1994). Bryman (2001) states that such an approach offers benefits within flexible research designs when the research aim is to contextualize and describe phenomena. This study adopted an approach that allowed members of the research team to be participant observers in a real-world setting (Schwartz and Schwartz, 1955; Gold,

1958; Yin 2013). These included participating in the executive board meetings governing the relationship, a series of informal interactions with cluster members, and the semi structure interviews described above. The participant observations were collected from the regular attendance of the Executive Board of the relationship, these occurred monthly at first and then quarterly between the second and third years of data collection.

Additionally, data was collected from a separate form of direct observations, in which the author had adopted a passive role (e.g. monthly technical meetings). These direct observations allowed the researcher to retain a more passive role while observing interaction patterns and activities in a natural setting. This allowed for observations of the interaction patterns among specific actors without interfering in the overall design of the event (Silverman, 2015; Yin, 2013). Due to the sensitive and strategic nature of the content and to ensure confidentiality of the content being shared, the direct observations were not digitally recorded but field notes were permitted. The direct observations were collected through the attendance of (1) monthly technical meetings and (2) presentations that were focused on the relational context for public audiences. The meetings provided the relationship with a forum, where projects were presented to partners for knowledge progression and joint problem solving.

Field observations continued throughout the length of the project. The repeated observations and an intensive long-term involvement supported the development of an in-depth understanding of the phenomenon (Maxwell, 2009). This technique provided the opportunity to collect rich data through gaining a focus on the natural and real-life settings (Miles and Huberman, 1994). It is frequently applied within anthropological studies with the intention to understand naturally occurring phenomena and ordinary events in natural settings to develop a strong understanding of what real-life is like therein (Silverman, 2015).

Finally, the author had extensive access to relational development and coordination documents. These documents were initially intended for the management and coordination of the relationship and have allowed for a further longitudinal lens into the transactional/formal coordination of the relationship and the organizing techniques dating. Due to the congenial access that the author was provided, the author had access to the relational management historical database from the point of initiation in 2011. This secondary data enabled further triangulation and analysis for the purposes of the questions at hand (Glass, 1976). Secondary data were collected from internal documents, presentation materials from workshops and conferences, as well as information displayed in the public domain, such as press releases, books, articles, and website information. The benefit of retrieving the archival documents was that they augment evidence from other sources to identify corroboratory versus contradictory evidence (Wasserman and Faust, 1994). The key benefit of this secondary data access was to further explore the involvement and intentions of the network members, as well as extracting further information regarding the relations that exist in an objective way.

Analysis Methods

Utilising a process of interpretive categorization, the analysis began with a data reduction process in which a comprehensive database was drafted and all data labelled according to emerging first-order themes (Miles and Huberman, 1994; Gioia et al., 2013). All documents, field notes, and interviews were stored in electronic format and compiled into an electronic database. To allow for new patterns to be explored and emerge in an inductive way (Yin, 1994), data was assessed by way of thematic analysis (Miles and Huberman, 1994; Creswell, 2009). This enabled a more comprehensive opportunity to make sense of the ways in which the relational activities and their mechanisms emerged and formed. In the process of compilation, data was interpreted and tabularized according to the emerging first-order

thematic codes. Throughout the data collection, an iterative process of identifying themes continued until theoretical saturation and fresh insights could no longer be yielded (Yin, 1994).

As the analysis has focused on refining the structure of networked exchange and distilling compositional features, the early phases of the work also focused on providing a continual comparison of the actor-level features and their interactions amongst entities and sub-units (Wasserman and Faust, 1994; Gephart, 2004). This allowed the researchers to refine the theoretical similarities and differences amongst actors and more accurately engage with categorization. In allowing for fairness and range, data was then assessed into a chronology of core events and exhibited behaviours to allow for an overview of evolutionary processes. The objective was to provide a simplex view and non-directional understanding of relational linkages between internal and external actors (Hanneman and Riddle, 2005). The non-directional dichotomous relations of non-ordered pairs to was drafted to reveal relational interdependence and the conditions in which knowledge resource were exchanged. Final themes and observations were selected due to their pertinence in the dataset.

[Insert Table 2 about here]

[Insert Table 3 about here]

RESULTS

The Context and Diversity of Network Actors

The activities for value creation take place at this network level even though the processes governing that value creation may take place elsewhere. We sought to further contextualize the nature of overarching interactions and structural influence that entities have on the university-business relational functions. Through this approach, the extent of ‘access’ the network has through a less bounded view is revealed (Jarillo, 1994; Cross and Parker,

2004). The core of the innovation network is driven by the relationships enacted between the individual human actors, who are characterised by diverse knowledge resources and roles that contribute to the overall functioning of the network. The process of value realisation within innovation networks depends on the ways in which the individuals access and engage across diverse contexts.

These university structures often operate and compete across a broad scale of expertise and academic disciplines, thus exhibiting a high-level of similarity within knowledge-based resources available to industrial collaborators. They often are perceived to operate within disciplinary silos, given the variations in academic contexts across the body of departments that a typical university provides. However, the university observed often designed projects that incorporated several core knowledge bases. This allowed the allowed projects at the university level to operate in a way that yields diverse insights in the same manner that would be found within industrial projects. This was apparent throughout all forms of the data collected, and was often attributed as a core component of the relational success. This university ability to cross-boundaries and interact across diverse silo was an attractive feature to the organization. However, the members of the organization often attribute a similarly importance aspect of the functioning of this relationship to behavioural features and alignment that could be achieved. In emphasising the importance of behavioural context, a corporate director from the organization is quoted saying this during the interview:

“When we scouted the whole academic eco-system in the UK, and [this University] quickly rose to the top. Both as having lots of things that we were interested in, but also upon the very first interactions, an entity that we could really work with.” - Organization Interview Participant

Behavioural alignment between universities and organizations is multi-faceted and complex. Perceptions on the nature of these dyads and, thus, the outcomes of the relational exchange often are portrayed as providing access to developments within fundamental

sciences. It is widely acknowledged that university-business relational dyads can be built for accessing the scientific knowledge-base of a region and for advancing economic opportunities. Yet, there are important distinctions between the contexts of academic and industrial science, especially within the process of commercialising technologies. Several participants suggested that it was common (amongst other) university-based collaborators to overlook the necessity for industrial applications and/or to be driven by the motivation to individually exploit technologies. However, they were often faced with challenges within that scientific context as the academics involved would also be keen to develop the process of commercialisation via spin-out organizations or other forms of entrepreneurial behaviour. Thus, yielding a mutual win for collaboration, within the remit of a university-business dyad, had exhibited an agency problem in prior relationships as they lacked the ability to craft distinct yet mutual wins for the partnerships.

Additionally, the potential for variations in the methods in which research is conducted, as well as perceptions of the asymmetric wins exacerbate the complexities of alignment that are not currently captured within of university-business relationships and often can result in misalignment. This emphasises the importance of focusing on the micro-level and individual behaviours to refine the compositional elements of the network. In creating the network, the partners in this dyad recognized that behavioural alignment was essential to effective functioning. For instance, an interview participant stated:

“Find common ground, things that the University, well not just the University but the individual, things that the principle investigator wanted to do that were in common with things [we] wanted to do. I had said that Universities tend to be more focused, in general towards fundamental research, but I would say that that changes at the individual principle investigator level. So, what I chose to do was to focus on those principle investigators that had that mindset.” - Organization Interview Participant

“My experience has been this intellectual win-win. That if you get industrial partners right, you get just as much good fundamental science out of a great industrial collaboration as industry gets strategic information and “know how” in the

investment world and commercial opportunities to create new products.... Two important ingredients are there.” - University Interview Participant

The organization recognised that there was an opportunity to access and engage with a collection of members at this university. As an entity, the university communicated a desire to work on applied technologies and formulated a process in which mutual beneficial scientific gains could be achieved. This encourage a collection of members from the university to align research expertise and identify potential academic outputs (e.g. publications and PhD research opportunities) embedded within the organization’s current industrial technologies and challenges. In doing so, they were equipped to appropriately respond to their career motivations and the commercial needs.

“When we wrote this proposal, we wrote it with kind of six different strands that we might work in. So, the corporate tech summarized those six but then at the end of it, we basically broke out into groups where people either talked about those themes or suggested their own ideas for areas where we could work [...] We produced a one-page form where the staff could submit and [...] a little panel that looked at those proposals. I forgot how many we got, twenty and something, and we chose the top 8 of them. And, as it turned out, of those 8 something like 2/3 of them were ideas that we were going to do anyways, and the other third were new ideas [...] So, we got to bring other people into the partnership. That was the sort of tactic to get the whole department involved. Give everybody an even chance.” - University Interview Participant

As a result of this process, the relationship formed in 2011. In the early days, this included 12 core projects and involved 22 academic staff, 5 corporate R&D technicians, 8 corporate administrators, 1 external collaborator, and governmental facilitating mechanism. This breadth of network involvement provided benefits in several ways. First, it allowed the relationships to form around individual motivations and the necessary knowledge resources for their project’s performance. Second, it facilitated knowledge spill-over activities on the micro-level. The initial 12 projects exhibited a high level of crossover in terms of alignment and expertise needs. Of the 27 integrated experts from both sides of the relational dyad, 12 were included in more 2 or more of the initial project scopes.

“Of the nine key technologies proposed, [this university] revealed their broad expertise in six areas and provided nineteen pieces of evidence to support this claim. One piece of work was that they shared these technology needs and they were given under headings. One of the things that we were able to do was to spend some time mapping where our expertise lie within each one of those themes. And then to align the right people to talk to them about those things. That is an example of what we did upfront to identify where the fit was.” -University Interview Participant

This form of coordination permitted valuable both knowledge spill-overs and diverse access to emerge between the projects. Recognizing the capability to capture these benefits, the actors met monthly to discuss the progress of their work and to discuss current analytical challenges they were facing. The invitation to attend these meetings were extended to all of the individuals engaged with any of the projects developed under the partnership. In doing so, it provided the opportunity to tap into the rich expertise and diversity currently available within the network, identify opportunities to advance the projects to the next phase, and identify potential resource solutions to addressing current gaps. The technology transfer sessions and progress reports were delivered by the PhD candidates. The presentation portions would typically last about an hour and would be followed by an open forum Q&A session for up to an hour and a half. Typically, attendance to the sessions would include 8-10 academic members of staff, 12 PhD candidates, and 3 corporate technicians. The activity observed were characterised by a variety of knowledge/expertise content roles and were from the physics, chemistry and biology departments at the university and local the technology managers within the organization. Thus, the analysis revealed a significant level of diversity of expert resources available within this network and contributing to the projects and the development of activity on the micro-level.

“We are working, scientifically, with the network of industrial scientists that we formulated the problems with right from the go. We involved them the whole way through. Second key ingredient is on the university side. You build an inter-disciplinary network of scientists of numerous of inter disciplinary network that is in industry all the time.” -University Interview Participant

A significant and understated benefit of the industrial context and the development of technology at the university lies within the ability to connect inter-disciplinary approaches within the remit of a single project scope and fosters deeper integration into the multi-discipline approach to solving scientific challenges. This unique configuration allowed a platform to inter-relate academic departments and extends beyond the traditional departmental silo format of many university structures. For instance, technical challenges could integrate project scopes across biology, chemistry, physics, and mathematics. This fosters the potential for novelty to emerge as it not only features a level of knowledge redundancy to allow for absorption but also exposure to diversity in new knowledge acquisition.

Additional evidence from the investigation suggests that the PhD members provided a networking impetus for some of the members. For instance, developments from the peripheral fringes of a project deepened the exchange between several of the established and core relational ties. Through the process of joint problem-solving sessions, members of the focal network became aware of the different streams of project scopes and often linked their needs with other working projects. This connection between previously disparate sources was fundamental in the process of creating new knowledge. The resources needed by the PhD candidates directly and indirectly ensured that a level of diverse access sustained in the innovation process. The members felt comfortable to share information freely within the bounds of the network. The knowledge shared was not exclusive technical but also included identifying potential external collaborators or expertise sources to contribute knowledge to the projects.

“I think that there is lots of winning points for the University. [...] I think that they are genuinely (1) great scientists, (2) they are good people and (3) they really want to see the projects succeed. So, that really helps. They are very responsive. They have a great faculty.” -Organization Interview Participant

Internal Network Agency and Structural Influence (Micro-Level Innovation Processes)

Built off the initial functioning and structure design of the initial projects, the network was delivering mutual-benefits effectively and generating innovations. In engaging with the network, the individuals entered into governance agreements that permitted in-group membership disclosure of technology developments. Yet, the projects were typically managed with a level of autonomy at the individual level. Due to the highly complex nature of the technologies being developed, not all knowledge complexities were solved within the remit of the focal actors. This was often due to the need for further scientific advancement and primary research to be conducted within the remit of the academic literature as well. Often, the tech transfer meetings often provided suggestions for additional members of either organization could enter and contribute knowledge resources.

“We foster partnerships with technologist(s) with a broad reach into innovation. So, I don’t focus a lot on researchers that are one and out. I focus on researchers that have a network. Influence the influencer, sort of. So, if I influence one and they are also influencers and so on.” - Organization Interview Participant

There has always been an interrelationship of the natural science disciplines, as each of these disciplines performs a specific role relating to the others. Chemistry is focused on understanding the chemical composition of our world and is often referred to as the central science due to its capability of connecting disparate fields within the physical sciences (Kuhn, 1962). This basis aids the communication platform for the shared language requirement of deriving innovation. Academic language from diverse disciplines has the potential to limit communication in this context, as specialized terminology can limit the extent to which ‘outsiders’ can internalise. However, through integrating the a focus on commercial technology provided a backdrop that reduced the typical departmental silos expected within a university.

“The way that [this relationship] has developed has absolutely modelled and shaped that strategy.... In the way that we allocate funding, in the way that we encourage a portfolio of activities and staff and projects that are purely in the lab here or with a partner. In the way that interact with government and funders. It’s changed that too, and the way we pursue opportunities. And in a way it has driven our interdisciplinary focus here as well.” -University Interview Participant

Additionally, this network needed to not only address communication and joint problem-solving forum where knowledge diversity and the process of innovation could emerge internally, but in response to the potential opportunities to access diversity of additional external relationships also held. The overall knowledge of capabilities, embedded within the commercial network form, facilitated unique knowledge exchange configurations.

However, there was not a top-level view of how the network(s) were scaling, evolving, and functioning. As the relationship grew in scale and diversity, the partners recognised that the relational dyad was increasing in complexity. However, the boundaries of a hierarchal structure were less clear within the network activity and the access to resources. The members of the relationship understood that the scale of collaboration was increasing over time and increasing the overall complexity, but this was occurring in organic ways.

Network Conditions for Boundary Spanning (Macro-Level Social Structure)

The volume of inter-organizational relationships a university and/or a business hold (either before or during) are likely to contribute (or impact) this type of collaboration. There are more than 40 external parties affiliated to the overarching relationship. This network is characterised by governmental units, public bodies, funding councils, non-competing companies, and other universities. It is apparent that knowledge and resource flows occur through a variety of internal and external subunits. Each of these stakeholders presents a unique blend of opportunities, yet a distinct set of challenges to the overall maintenance of individual projects let alone on the overarching relationship. For example, the alignment of

expectations among diverse partners is complex. Each partner's unique contributions and needs must be carefully coordinated to facilitate the acquisition of valuable resources. But such support also contains important implications for governance and coordination.

"I think very much so that it is still developing. I don't think that we have realized all of the potentials here. I think that we are still on the journey."

Realizing the extent of partners within the network, boundary specification was set to limit data collection between actors at the University and the organization. There is considerable evidence that the knowledge flows from external sources are extensive. This relationship facilitates access to external engagement on a broader scale. However, each relationship for potentially represents a different level alignment. Additionally, their level of influence varies as well in terms of formal mechanisms (e.g. reporting and impact) and informal mechanisms (culture, trust, and behaviour.)

The over-arching aim of business engagement activity is to enhance the quality of research and to further develop the research impact (whilst) building long-term mutually beneficial (..) partnerships

The most influential example of this was the role of a funding body in the early stages of the relationship that, in return for several million Pounds of research funding, implemented oversight by inserting a third-party collaborator, requiring the involvement of local businesses, and necessitating regular joint meetings of projects funded through the initiative. While this might be interpreted as bureaucratic oversight and interference into the governance and coordination of projects central to the overarching relationship, this set of requirements provided a further platform for increased frequency of meetings between the network members and particularly in the early stages of the relationship. By requiring greater interaction and coordination of activities, this helped to accelerate the maturity of the network structure, adding momentum to the growth of the relationship.

The impact of institutional forces should not be ignored in terms of its importance or value to the development of the relationship. While it may be tempting to focus inwardly on the relationship alone, members of the ‘open’ network can bring valuable resources and knowledge but their actions in specifying contingencies onto the management. Treating these external parties as valuable partners instead of as mere resource holders can path-dependently shape the relationship and its effectiveness. This grew the breadth of the relationship as well as the social capital extended to external parties, benefiting the stakeholders financially through resource acquisition and non-financially through improved governance and knowledge generation. Through allowing the partners on either side to access the resources within their personal network signifies trust, as revealing such contacts has the potential to jeopardize reputation and established social capital.

The direction and influence of the activities occurring within this level of network influence the actor’s access and awareness of external resources. The boundaries of this ‘open’ network is likely to include a vast number of actors and is beyond the scope of this study. It must be acknowledged that one of the advantages of the open level network ties was its provision of financial resources to rapidly set up new projects and that the degree of the linkages that internal actors hold is key to ensuring the vitality, sustainability, and continued productivity of novel resources as it promotes heterogenic knowledge. It also lent credibility and prestige to the relationship in its early years, encourage more individuals to become involved. As the relationship evolved, the value and volume of external connections were recognised as essential to the core functioning of the relationship.

Network Orchestration and Governance Behaviour

The network within a university and business collaboration is more dynamic than typical one mode analysis. A one mode network would indicate that all the actors are from a single entity, and that network is comprised of actors for a singular social system with

aligning goals. A network with actors from two different social systems are called two mode network. For instance, a business's overall objective lies within marketable value creation whereas a university has the objective of knowledge creation. The partners share differing overall objectives, for instance profit and not-for-profit, this gives rise to a two-mode network. As such, this type of relationship is often characterised to have bi-directional resource flows (Wasserman and Faust, 1994; Hanneman and Riddle, 2005). Dyadic analysis of two mode network is a technique that seeks to describe the relationship ties between two actors and is characterised by several different forms linkages that tie the organizations together. This aims to theorise the methods at which relationships are ties are reciprocated (Wasserman and Faust 1994).

Prior to any further network ties forming within the 'relationship' (defined as the overarching relationship), the partnership first needed to formulate governance and transactional coordination that would regulate the projects that would develop in the face of increasing network complexities. The overarching governance (e.g. the board) formed to monitor these dynamics, and begin formal a process of capturing its successes to demonstrate its value and legitimacy to internal (e.g. corporate headquarters, business units) and external (e.g. suppliers, funding bodies) stakeholders. This board led to an extensive action by the network for the benefit of the relationship.

These documents brought new budget and were really, we were chartered to do a lot of the work with external partners and that provided the impetus to be able to work with [this University]. And, then as we started to develop what we wanted to accomplish for the company, we saw in [this university] was that there were lots of partnerships, lots of people that could do things that could be of value to us.
Organizational Research Participant

There was purposeful action to identify and connect with and from the existing but separate set of ties with external parties held by individual actors. While offering its own resources, and presenting its own opportunities, the actors operating within this network had

a profound effect on the governance and coordination of the overarching relationship. Therefore, the socio-gram further illustrates the interactions between these varying networks. However, the members of the relationship understood that the scale of collaboration was increasing over time and increasing the overall complexity. Table 4 demonstrates the complex nature of the relational exchange.

[Insert Table 4 Here]

Whilst the governance board focused on providing facilitating mechanisms to enable the diverse interactions needed to fuel the innovation activities, the affects of additional oversight were observed in the tech transfer processes occurring micro-level network composed of R&D scientists. This level of network coordinates and shares the complex knowledge necessary for innovation performance. While it was anticipated that the observations would include actors from both organizations, it became apparent that the systems of activities were embedded within a broader range of network activities and external parties. Additional oversight mechanisms controlled the process at which core-actors would engage in boundary-spanning activities. Our analysis reveal the extent the structure of these activities.

DISCUSSION AND IMPLICATIONS

This study contributes to the cluster formation and effectiveness literature by exploring how relationships form to fill resource gaps within regional and geographic clusters. The cluster formation literature suggests that relational behavior features exist within clusters, but has yet to uncover the antecedents to their effectiveness and to cluster effectiveness. Through focusing on the behaviours and activities of individuals in an influential and highly effective business-university relational dyad, embedded within a resource constrained regional ecosystem, using a micro-level view of the complex

interactions embedded with relational dyad, this study suggests that clusters increase their relational and collaborative effectiveness through enabling autonomous boundary spanning activities of the individual actors involved in the relationship. We shed specific light on individual agency as a micro-level network, their boundary spanning behavior, and conditions for boundary spanning. The relational dyads built between organizations are often complex in and of themselves. By focusing on the individuals embedded within a single relational dyad, we identify their role in filling resource gaps and key factors impacting their effectiveness to generate collaborative innovations. To our knowledge, there has not been another study to date that has attempted to understand cluster formation and relational development employing the rich data collection ethnography provides. This study provides several theoretical contributions and practical implications.

Most networks are not completely bounded within the confines of a single social structure, and an entire network of activity can prove to include a vast number of actors (Bernard and Killworth, 2006). The scope of value creation is typically attributed to the structural features of a network (Koka and Prescott, 2002; Larson, 1992) and subsequent variance in tie strength and quality among actors (Burt, 1995; Uzzi, 1996, 1997; McEvily and Zaheer, 1999; McEvily and Marcus, 2003; Reagans and McEvily, 2003). Indeed, a recognized determinant of regional cluster performance is in the *behaviour* of internal actors to engage in the organic formation of ties to peripheral nodes to increase the scope and diversity of knowledge sources (Granovetter, 1973; Krugman, 1991; Feldman, 1994; Burt, 1995).

We shed new light on this behaviour. The interdependent nature of actors (nodes) and the relational linkages (ties) determine the flow of resources (e.g. social capital and knowledge) within a network (Wasserman and Faust, 1994; Sedita, 2008) and the act of resource diffusion through the relational links to each actor (Robertson, Casali, and Jacobson,

2012; Pentland, 2014) and suggest determinants of sharing knowledge within a network capable of impacting innovation as a feature of collective performance. For instance, there is an emphasis on the role of network promoters in open innovation (Fitcher, 2009) as well as the importance of internal knowledge brokers (Cillo, 2005). There are also theoretical tensions in the network literature regarding the usefulness of structural holes (Burt, 1995) and strength of weak ties for innovation performance in collaborative networks (Granovetter, 1973; Ahuja, 2000). These authors argue that a network characterized by high levels of density will result in knowledge redundancy and that weak links provide novel information (Marriott and Delbridge, 2012). A counter argument supports high levels of embeddedness and strong ties (Uzzi, 1996; 1997) as contributing to the acquisition of competitive capabilities and the complex knowledge transfer necessary for innovation performance (McEvily and Marcus, 2005).

To illustrate our contribution, individual human agents' *boundary spanning activity* is essential to value creation in and beyond the cluster. Individuals in our data boundary spanned in two specific ways. First, despite having a specific functional home (or subunits, e.g., chemistry, biology, etc.), core individuals had *internally-authorized autonomy* to connect with other functions and were supported in their projects by *agents on the periphery*. These peripheral members infused core members with new knowledge, joint problem solving and developments from related and unrelated projects. Thus, *internal boundary spanning* generated new knowledge and yielded expert resources. However, this creates *internal oversight* and *coordination* challenges that were solved through establishing an *internal governance board* and *general master agreement* to internally oversee the full range of activities taking place in the network. This was further required because the network *oscillated* over time as new *members* left and new internal and external *pressures* emerged. Internal resources, of course, are finite which led individual agents to exhibit *external*

boundary spanning – boundary spanning to external entities to gather new resources for the cluster. These *external entities*, however, act on individual agents within the cluster. External resource acquisition brings *oversight* directly to individual agents but that oversight extends to the wider network and cluster as these entities become more embedded. Thus, while individual agents require internally-authorized autonomy in the first place to engage in internal and external boundary spanning, that autonomy was later at risk due to *stricter external oversight* on the use of supplied resources. External entities then created an inadvertent pressure for further governance and network orchestration. For senior managers, the challenge was then to coordinate the involvement of individuals from across internal subunits and external entities or lest the cluster and network spiral in unplanned or unforeseen ways. Ultimately, managing these conditions to support the internal and external boundary spanning of individual agents in the network were essential for the *vitality* of the cluster and for *innovation* outcomes to generate.

In sum, our case findings provide rich insights into the behavior of individual agents and their essential role in cluster effectiveness, coupled with a distillation of the conditions both within and beyond the cluster acting on the boundary spanning behavior of these individuals.

Implications for Managers and Policy-makers

A primary practical implication of our work is that it emphasizes the importance of embedding enabling factors [e.g. policies and practices] for individuals in cluster formation initiatives. Science and innovation audits often focus on the development of regional and geographic collaborative activities through a process of co-location. In doing so, policies and incentives are designed to encourage new business formation and/or relocation to a specific geographic location. However, our findings suggest that this is only a small piece of the

‘cluster development and effectiveness’ puzzle. Most importantly, the effectiveness of clusters and co-location advantages are attributed to the strength and value of networked relationships for reciprocated knowledge exchange and collaboration at the dyadic and individual levels. Within these networks, firms may reciprocate and distribute resource stocks, but alignment between resource portfolios and governance practices will not emerge without a coordinated effort. This is because complex variations in organizational objectives make it difficult to define and orchestrate relational activities. By designing enabling factors that allow for actors, who are currently embedded within these newly forming clusters, to exhibit a level of autonomy and agency in identifying and connecting with external clusters, organizations, and pools of knowledge, they may be able to overcome the complexities of relational alignment and access the resources not currently available within the region. Over time, this boundary spanning activities, that occurs between actors on the micro-level, has the potential to attract re-location of their partnerships, as their relationships increase in strength and activities. This is not to say that the current focus of co-location within current political agendas is poor. Increasing the volume of organizations within a region provides more potential for relational development opportunities. However, our findings demonstrate that it alone is not enough to drive the effectiveness.

The micro-level approaches to analysis limit the boundaries to individual level and the types of relations embedded within. The process of innovation and sharing knowledge occurs within the micro-level if the network. However, the university-business relational exchange is impacted on by several significant and powerful external forces and, as evidenced, the management and coordination of those external institutions plays a significant role on the internal behavior, opportunity identification, and internal management of individuals and their boundary spanning activity. Managers and policy-makers should act with caution to anticipate and detect how Ccomplex and significant pressures from various external

institutions can act on the effectiveness of the relationship and individual agents boundary-spanning activity in particular. Policy makers must realise that the oversight applied as a function of providing external resources raises further governance and coordination challenges for managers. While such oversight is justified, strict rules or restrictions may deplete individuals' ability to boundary span beyond their projects and create new linkages for knowledge sharing and innovation. For managers, engagement with policy-makers and other external entities creates further coordination challenges that can only be resolved through good governance. A solution is to involve these external entities directly in the cluster's activities and orchestrate the relationship between individual agents in the cluster and actors in the external parties.

Limitations and Future Research

Some limitations impinge upon the contributions of our study, and these open important avenues for future research. First, the key limitation to social network data is the ability to generalize social phenomena to other social situations. Although the data collection techniques and analysis followed a robust research design, there are limits to determining the applicability of this relational structure based on the analysis of the 'local' interaction. Future work could be used to extend this analysis for cross case analysis. Second, data access to the entirety of the external stakeholders would have benefited the analysis of the open systems that influence this network but was beyond the scope of this study. Third, people in cohesive groups can think of themselves as superior members (Myers and Lamm, 1976) in ways that may affect their views of the network and its functioning. Tied to this, the success of the activities of one group can filter through to another group due to in-group membership and the representations of the self. Within in-group membership, achievements are identified among the group members as a whole. Ingratiation (conveying the impression of being

likable), self-promotion, and competence display are common goals of social interaction (Arkin, 1981; Lerner, 1995). While the research design used multiple data points to allow for triangulation, which further allowed for the verification of the existing linkages, some of the network externality data was collected via self-reporting mechanisms. Future research studies may wish to focus on these individual- and group-level matters to further examine the functioning of relationships within a bounded network cluster from and through a holistic observation of both focal and peripheral network actors.

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Table 1: Semi Structured Interview Participants

Title	Expertise Area	Role in Network
Corp Director	Physics	Coordinator (Top)
Corp Director	Chemistry	Coordinator (Biology)
Corp Director	Chemistry	Coordinator (Chemistry)
Tech Mang.	Chemistry	PI
Corp Director	Chemistry	Coordinator
Corp Director	Biology	Coordinator (Top Biology)
Corp Director	Biology	Coordinator/PI
Tech Mang.	Chemistry	PI
Corp Director	Chemistry	Coordinator (Admin)
Corp Director	Physics	Coordinator (Admin)
Intern	Biology	Coordinator
Head of Dept	Physics	Coordinator/PI
Head of Dept	Physics	Coordinator/PI
Head of Dept	Chemistry	Coordinator/PI
Head of Dept	Biology	Coordinator/PI

Table 2: Actor Attributes

Attribute	Description
Knowledge Content	Area of Expertise University-Business Prior Experience
Subgroups	Departments Organization
Relationship Tenure	Strong or Weak Tie
Professional Status	Career Level
External Engagement	Volume of Partners Engaged on Projects
Demographic	Age Gender
Projects	Volume Date of commencement

Table 3: Overview of Data Collected

data source	Classification of Core Assumptions	Volume and Sources of Data	First Order Themes	Pertinent Thematic Observations
Primary	Participant Observation	Board Meetings (14)	Governance	Legitimacy Opportunity Identification Mechanical Oversight Resource Facilitation Boundary Spanning
		Semi-Structured Interviews (15)	Relational Composition Governance	Actor-level Role Knowledge Transfer Resource Acquisition Relational Tenure Boundary Spanning
		Informal Meetings (9)	Relational Composition	Legitimacy Actor-level Role Relational Tenure
	Direct Observation	Technical Meetings/Joint Problem Solving (18)	Broader Cluster Engagement	Knowledge Transfer Resource Acquisition Internal Engagement External Engagement Boundary Spanning
		Public Presentations (2)	Broader Cluster Engagement	Knowledge Transfer Resource Acquisition Internal Engagement External Engagement Boundary Spanning
	Cross-Sectional	Descriptive Survey (67)	Relational Composition	Actor-level Role Knowledge Transfer Resource Acquisition Relational Tenure Boundary Spanning
	Content	Archival Documents (contracts, etc.) (223)	Relational Composition Broader Cluster Engagement Governance	Knowledge Transfer Resource Acquisition Internal Engagement External Engagement Actor-level Role Relational Tenure Legitimacy Opportunity Identification Mechanical Oversight Resource Facilitation Boundary Spanning

Table 4: The Relational Structure of University-Business Cluster Involvement

